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VEHICLE TRAVELING SPEED PATTERN ESTIMATION DEVICE/METHOD

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2003-068685 filed on March 13, 2003 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of Invention

[0002] The present invention relates to a vehicle traveling speed pattern estimation device/method.

2. Description of Related Art

[0003] Hybrid vehicles employ, as power sources, both an engine such as an internal combustion engine or the like and a motor such as an AC motor or the like driven by electric power supplied from an electric power accumulation means such as a battery (a secondary battery). In the hybrid vehicle, the motor, which serves as one of the power sources, also functions as a generator during deceleration of the vehicle. In the case where so-called regenerative current is generated, the regenerative current is supplied to the battery during deceleration of the vehicle, so that the battery is recharged. Thus, the battery is constantly charged, and current is automatically supplied to the motor from the battery via an inverter, for example, in the case where output of the engine is below a required output. Therefore, the vehicle can stably travel in various traveling modes. Further, the amount of fuel consumed by the engine can be reduced.

[0004] To minimize the amount of fuel consumed by the engine, it is known to set operational schedules for the engine and the motor in such a manner as to minimize the amount of fuel consumption in accordance with traffic conditions on a

route to a destination (e.g., see Japanese Patent Application Laid-Open No. 2000-333305, Japanese Patent Application Laid-Open No. 2001-183150, and Japanese Patent Application Laid-Open No. 2003-9310). In this case, the route to the destination is divided into a plurality of sections, a traveling speed pattern for each of the sections is estimated by acquiring road data and traveling history from a navigation system, and operational schedules for the engine and the motor are so set as to minimize the amount of fuel consumed in driving to the destination, on the basis of the estimated traveling speed pattern and fuel consumption characteristics of the engine.

[0005] However, in the above-mentioned vehicle traveling speed pattern estimation system of the related art, the precision in estimating a traveling speed pattern is low, and an attempt to enhance the precision of estimation leads to an increase in the burden of estimation processing.

[0006] As a rule, in the case where a traveling speed pattern is estimated, it is desirable that the travel speed pattern be estimated on the basis of the past travel data on a route that is estimated to be followed from the current position. In the vehicle traveling speed pattern estimation system disclosed in Japanese Patent Application Laid-Open No. 2000-333305, a traveling speed pattern for a route to be followed is estimated on the basis of the past travel data and various road attributes (class of road such as expressway, open road, urban area, and the like). However, in the vehicle traveling speed pattern estimation method disclosed in Japanese Patent Application Laid-Open No. 2000-333305, since data for routes other than the route to be followed are also included in the past travel data, the precision in estimating a traveling speed pattern for the route to be followed suffers.

[0007] In the vehicle traveling speed pattern estimation system disclosed in Japanese Patent Application Laid-Open No. 2000-333305, a traveling speed pattern is estimated in accordance with time zone, day of the week, and the like. In this case, when making use of the past data for a route that is estimated to be followed, the precision in estimating a traveling speed pattern can be enhanced by basing the estimation on data for previous travel matching conditions of the travel environment to be encountered through in current travel, in accordance with time zone, day of the week, and the like. However, if the past data available for

estimation is screened in accordance with day of the week or time zone, the amount of available past data is reduced, and the precision of estimation is reduced, rather than enhanced as intended. Further, if accumulation of the past travel data is continued, the volume of the accumulated data becomes enormous. If an enormous volume of data is utilized as the past travel data in estimating a traveling speed pattern, the burden of calculation processing is increased, and the installation of high-performance calculation means becomes necessary.

SUMMARY OF THE INVENTION

[0008] As a solution to the problems of the vehicle traveling speed pattern estimation device of the aforementioned related art, the present invention aims at providing a vehicle traveling speed pattern estimation device/method which makes it possible to efficiently estimate a traveling speed pattern without referring to an enormous volume of the past travel data in estimating the traveling speed pattern on the basis of the past travel data, and which prevents imprecise estimation due to a lack of availability of past data.

[0009] To achieve this object, according to one aspect of the present invention, a vehicle traveling speed pattern estimation device comprises traveling information storing means for storing travel data and travel environment data as mutually associated data, candidate traveling speed pattern generating means for generating candidate traveling speed patterns on the basis of the travel data, and estimated traveling speed pattern outputting means for extracting a candidate traveling speed pattern matching current travel environment data and outputting an estimated traveling speed pattern for a route to be followed from the current location.

[0010] In the above-mentioned aspect of the present invention, the vehicle traveling speed pattern estimation device may further comprise frequent route specifying means for specifying a frequently used route on the basis of the travel data, and sectionally dividing means for dividing the frequently used route into short sections. In this vehicle traveling speed pattern estimation device, the candidate traveling speed pattern generating means may generate the candidate traveling speed pattern for each of the short sections, and the estimated traveling

speed pattern outputting means may extract a candidate traveling speed pattern for each of the short sections and output an estimated traveling speed pattern for a frequently used route to be followed.

[0011] In the above-mentioned aspect of the present invention, the candidate traveling speed pattern generating means may classify the travel data for each of the short sections on the basis of an average travel speed for each of the short sections or a degree of similarity among traveling speed patterns for each of the short sections, and generate a traveling speed pattern representing a set of the classified travel data for each of the short sections as the candidate traveling speed pattern.

[0012] In the above-mentioned aspect of the present invention, the estimated traveling speed pattern outputting means may extract travel data matching current travel environment data for each of the short sections, extract a candidate traveling speed pattern representing a set to which the greatest number of matched items of travel data belong, and output the estimated traveling speed pattern.

[0013] In the above-mentioned aspect of the present invention, the travel environment data may include date, hour, day of the week, information on operation of on-board equipment such as wipers and headlights, and sensed information obtained from on-board sensors such as a raindrop sensor.

[0014] In another aspect of the present invention, a vehicle traveling speed pattern estimation method comprises the steps of storing travel data and travel environment data as mutually associated data, generating candidate traveling speed patterns on the basis of the travel data, and extracting a candidate travel speed pattern matching current travel environment data and outputting the extracted estimated traveling speed pattern for a route to be followed from the current position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Fig. 1 is a block diagram of an embodiment of a drive control system for a hybrid vehicle in accordance with the present invention;

[0016] Fig. 2 shows an example of a drive control table for the hybrid vehicle in accordance with the embodiment of Fig. 1;

[0017] Fig. 3 is a flowchart of overall operation of a vehicle traveling speed pattern estimation system of the embodiment of Fig. 1;

[0018] Fig. 4 is a flowchart of a frequently used route specification routine utilized in the embodiment of Fig. 1;

[0019] Fig. 5 shows an example in which a frequently used route is divided into a plurality of short sections;

[0020] Fig. 6 shows an example of travel data for short sections in the embodiment of Fig. 1;

[0021] Fig. 7 shows a first example of travel data for classified short sections in the embodiment of Fig. 1;

[0022] Fig. 8 shows a second example of travel data for classified short sections in the embodiment of Fig. 1;

[0023] Fig. 9 shows a third example of travel data for classified short sections in the embodiment of Fig. 1;

[0024] Fig. 10 shows a first example of a representative traveling speed pattern for classified short sections in the embodiment of Fig. 1;

[0025] Fig. 11 shows a second example of a representative traveling speed pattern for classified short sections in the embodiment of Fig. 1;

[0026] Fig. 12 shows a third example of a representative traveling speed pattern for classified short sections in the embodiment of Fig. 1;

[0027] Fig. 13 shows an example of classification of travel data for all the short sections of a frequently used route in the embodiment of Fig. 1;

[0028] Fig. 14 is a flowchart of a candidate traveling speed pattern generation routine utilized in the embodiment of Fig. 1;

[0029] Fig. 15 shows an example of estimation of travel data for all the short sections of a frequently used route in the embodiment of Fig. 1;

[0030] Fig. 16 is a flowchart of a traveling speed pattern estimation routine in the embodiment of Fig. 1;

[0031] Fig. 17 shows a first example of a set schedule in the embodiment of Fig. 1;

[0032] Fig. 18 shows a second example of a set schedule in the embodiment of Fig. 1;

[0033] Fig. 19 is a flowchart of a scheduling routine utilized in the embodiment

of Fig. 1; and

[0034] Fig. 20 is a flowchart of a travel routine utilized in the embodiment of Fig. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0035] Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

[0036] Referring to Fig. 1, a reference numeral 10 denotes a drive control system of a hybrid vehicle as a vehicle traveling speed pattern estimation device in the present embodiment, and a reference numeral 20 denotes a drive unit. An engine 21, such as an internal combustion engine or the like, is driven by fuel such as gasoline, light oil, or the like. The engine 21 is provided with an engine control unit such as an ECU (not shown) or the like, and is used as a power source for a vehicle such as a passenger car, a bus, a truck, or the like. Driving force of the engine 21 is transmitted to transmission unit 25, a drive shaft (not shown), drive wheels (not shown), and the like. The vehicle is driven by rotation of the drive wheels. A braking unit such as a drum brake, a disc brake, or the like can also be included in the transmission unit 25.

[0037] It is to be noted that in this embodiment the vehicle is a hybrid vehicle. This hybrid vehicle has a motor 24 such as an AC motor or the like, and utilizes both the engine 21 and the motor 24 as vehicular power sources. The motor 24 generates a driving force by electric power supplied from a battery 23 as electric charge accumulation means. The driving force is transmitted to the drive wheels of the transmission unit 25. A generator 22 such as an AC generator or the like is connected to the transmission unit 25. The generator 22 generates a regenerative current during deceleration of the vehicle, which regenerative current is supplied to the battery 23, whereby the battery 23 is charged. The generator 22 can also generate current when driven by the engine 21. It is desirable that the motor 24 be an AC motor, in which case, the motor 24 is provided with an inverter (not shown). By the same token, it is also desirable that the generator 22 be an AC generator, in which case, the generator 22 is provided with an inverter (not shown). In addition, the battery 23 is provided with a capacity detecting sensor (not shown) for detecting an SOC (State Of Charge) as the amount of

electric charge accumulation.

[0038] The motor 24 may be constructed integrally with the generator 22. In this case, the motor 24 generates a driving force and functions as a power source when being supplied with electric power from the battery 23, and functions as the generator 22 for generating regenerative current when rotated by the transmission unit 25, as in the case of braking of the vehicle or the like.

[0039] The battery 23 is a secondary battery and serves as an electric charge accumulation means that allows repeated charge and discharge of electricity repeatedly. In general, a lead-acid battery, a nickel-cadmium battery, a nickel-hydrogen battery, or the like is used as the battery 23. However, the battery 23 may also be a high-performance lead-acid battery as used in an electric vehicle or the like, a lithium ion battery, a sodium-sulfur battery, or the like. It is not absolutely required that the electric charge accumulation means be the battery 23. The electric charge accumulation means may be in any form as long as it functions to store and discharge electricity. For example, the electric charge accumulation means may be a condenser (capacitor) such as an electric double layer condenser, a flywheel, a superconducting coil, a pressure accumulator, or the like. Furthermore, while one of the foregoing accumulation means may be used alone, some of them may also be used in combination with one another. For example, the battery 23 and the electric double layer condenser may be combined with each other and used as the electric charge accumulation means.

[0040] A main control unit 26, which is a type of computer includes calculation means such as a CPU (not shown), a MPU (not shown) and the like, storage means such as a semiconductor memory, a magnetic disk and the like, a communication interface, and the like. The main control unit 26 controls operations of the engine 21, the engine control unit, the motor 24, the generator 22, and the inverter on the basis of signals from a traveling pattern predicting section 11, the capacity detecting sensor, and various sensors in a travel data acquiring section 13. The aforementioned sensors include an accelerator sensor, a brake sensor, and the like. These sensors detect items of information on operations performed by a driver of the vehicle, and transmits them to the main control unit 26.

[0041] The main control unit 26 usually controls the manner in which needed

power output is allocated between the engine 21 and the motor 24 ("usage ratio") in accordance with the traveling circumstances of the vehicle, for example, as shown in Fig. 2. In this case, the output during travel of the vehicle is defined as 100 %, i.e., the sum of an output from the engine 21 and an output from the motor 24 is defined as 100 %. For instance, while the engine 21 and the motor 24 may be operated respectively with usage ratios of 80 % and 20 % with respect to the total power required by the vehicle in traveling up an incline of +8 % or more, they may also be operated respectively with usage ratios of 70 % and 30 % of the total output of the vehicle, for example. Thus, the usage ratios shown in Fig. 2 represent nothing more than one example. That is, the numerical values given under the headings "UPHILL ROAD (+) OR DOWNHILL ROAD (–)", "VEHICLE SPEED", "ENGINE", and "MOTOR" can be changed appropriately. In other words, the usage ratios of the engine 21 and the motor 24 with respect to the total output during travel of the vehicle can be set using a table totally different from the table shown in Fig. 2.

[0042] Referring to Fig. 1, a navigation data base 12 stores pieces of navigation information as data to be used for navigation processing in a commercially available navigation system, for example, map data, road data, search data, and the like. A travel environment data acquiring section serves to acquire data on the travel environment of the vehicle such as time, date, traffic congestion information, weather information, and the like. The travel data acquiring section 13 is provided with various sensors, and acquires data on the traveling state of the vehicle such as vehicle speed, operational state of a brake, accelerator opening, and the like. The traveling pattern predicting portion 11 also operates as a computer and includes calculation means such as a CPU (not shown), a MPU (not shown) and the like, storage means such as a semiconductor memory, a magnetic disk and the like, a communication interface, and the like. The traveling pattern predicting section 11 acquires data from the navigation data base 12, the travel data acquiring section 13, and the travel environment data acquiring section 14, executes navigation processing such as display of the current position of the vehicle, search of a route to a destination, and the like, and executes a traveling speed pattern estimation reflecting driving characteristics of the driver. It is desirable that the traveling pattern predicting section 11 be

provided with an input portion, a display portion, a speech input portion, a speech output portion, and a communication interface. The input portion is provided with an operational key (not shown), a press button, a jogdial®, a cruciform key, a remote controller, or the like. The display portion is provided with a CRT display, a liquid-crystal display, a LED (Light Emitting Diode) display, a plasma display, a hologram system for projecting a hologram onto a windshield, or the like. The speech input portion is composed of a microphone and the like. The speech output portion is provided with a speech synthesizer, a loudspeaker, and the like. The communication interface exchanges various data with an FM transmitter, a telephone line network, internet, a mobile phone network, and the like.

[0043] The navigation data base 12 is composed of various data files. The navigation data base 12 includes not only search data for searching a route but also various data such as map data, facility data, and the like, for displaying a guide map on a screen of the display portion along a searched route, displaying a photo, a frame shot, or the like that is characteristic of an intersection or a route, displaying distance to the next intersection, direction of travel at the next intersection, and the like, and displaying other pieces of guide information. Various data for outputting predetermined items of information by the speech output section are also recorded in the navigation data base 12.

[0044] The search data includes intersection data, road data, traffic regulation data, and route display data. In addition to the number of intersections for which data is stored, data on the respective intersections is included in the above-mentioned intersection data, as intersection data accompanied by respective identification numbers. Moreover, in addition to the number of roads connected to each of the intersections, namely, the number of connecting roads, numbers for identifying the connecting roads are stored as attachments corresponding to the intersection data. Intersection types may be included in the intersection data. Namely, data for determining whether or not each of the intersections is equipped with traffic signals may be included in the intersection data.

[0045] In addition to the number of roads for which data is stored, data on the respective roads is included in the above-mentioned road data, as road data accompanied by respective identification numbers. In the data for each of the

roads, the type of road, a distance as a length of that road, a travel time as a time required for travel along that road, and the like are stored. The types of roads are identified by administrative attribute such as national highways, prefectural highways, main regional roads, open roads, expressways, and the like.

[0046] It is desirable that the road data include road-related data such as width, gradient, cant, altitude, bank, road surface state, the presence of a median strip, the number of lanes, a position where the number of lanes decreases, a position corresponding to a narrowed width, and the like. Opposite lanes of an expressway or a trunk road are stored as separate road data and treated as two roads. For example, a trunk road having two or more lanes on one side thereof is treated as two roads. The opposing lanes of the trunk road are stored in the road data as mutually independent roads. Furthermore, for a corner, it is preferable to include data on radius of curvature, intersection, T-junction, corner entry position, and the like. Road attributes such as railroad crossing, ramp at entrance or exit of expressway, toll gate for expressway, downgrade (decline), upgrade (incline), and the like may also be included.

[0047] The data in the navigation database 12 is stored in storage means such as a semiconductor memory, a magnetic tape, a magnetic disk, a magnetic drum, a flash memory, a CD-ROM, an MD, a DVD-ROM, an optical memory disk, an MO, an IC card, an optical memory card, a memory card, or the like. It is also possible to use a removable external storage medium.

[0048] The travel data acquiring section 13 has a GPS sensor for receiving GPS information from a GPS (Global Positioning System) satellite, an orientation sensor for detecting the direction in which a vehicle is oriented, an accelerator opening sensor for detecting the opening of an accelerator, a brake switch for detecting the movement of a brake pedal operated by the driver, a steering sensor for detecting the steering angle of a steering wheel operated by the driver, a turn signal sensor for detecting movement of a turn signal lever operated by the driver, a shift lever sensor for detecting movement of a shift lever by the driver, a vehicle speed sensor for detecting travel speed of the vehicle, namely, the vehicle speed, an acceleration sensor for detecting acceleration of the vehicle, a yaw rate sensor for detecting yaw rate indicative of a change in the direction in which the vehicle is oriented, and the like. The travel data include current position of the vehicle,

opening of the accelerator, operation of the brake pedal by the driver, steering angle of the steering wheel operated by the driver, operation of the turn signal lever by the driver, a movement of the shift lever by the driver, vehicle speed, acceleration of the vehicle, yaw rate indicative of a change in the direction in which the vehicle is oriented, and the like.

[0049] The travel data acquiring section 13 acquires travel data such as current position of the vehicle, traveling speed of the vehicle, and the like at predetermined intervals between starting and stopping of the vehicle, namely, between start and stop of the drive unit 20. That is, the travel data acquiring section 13 acquires travel data at intervals of a predetermined period (e.g., every time a predetermined period such as 100 msec, 1 sec, or the like elapses) or at intervals of a predetermined distance (e.g., every time a predetermined distance such as 100 m, 500 m, or the like is covered). The acquisition of travel data at predetermined intervals as described herein makes it possible to obtain travel loci of the vehicle and moment-to-moment changes in travel speed of the vehicle, namely, a traveling speed pattern of the vehicle. The travel data thus acquired can be utilized to produce or estimate a traveling speed pattern by the traveling pattern predicting section 11.

[0050] The travel environment data acquiring section 14 is provided with a clock, a calendar, and the like. The travel environment data acquiring section 14 acquires and stores date-and-time information such as the current time, date, day of the week, date and time of departure of the vehicle, and the like. Further, the travel environment data acquiring section 14 acquires and stores traffic information, such as items of information on traffic congestion and the like, items of information on traffic regulations, items of information on road construction, and the like. These items of information are prepared by gathering information from traffic control systems of Japan Public Roads Administration, the police, and the like, for example, using a road traffic information communication system called VICS(R) (Vehicle Information & Communication System). In addition, it is also desirable that the travel environment data acquiring section 14 acquire and store event information such as planned spots, dates, hours, and the like for organized events such as festivals, parades, fireworks displays, and the like. For instance, it is also desirable that the travel environment data acquiring section 14 acquire and store

statistical traffic congestion information indicative of the possibility of traffic congestion on roads in the neighborhood of a railway station or a major commercial establishment at a certain hour of workdays and the possibility of traffic congestion on roads in the neighborhood of a bathing beach during summer vacation, weather information such as a weather forecast produced by the Japanese Meteorological Agency, and the like. The travel environment information, i.e., information on the environment in which the vehicle travels, which are acquired and stored by the travel environment data acquiring section 14, includes the current time, date, day of the week, date and hour of departure of the vehicle, weather, traffic congestion information, traffic regulation information, road construction information, event information, and the like.

[0051] The travel environment data acquiring section 14 also acquires data on operating conditions of on-vehicle equipment such as wipers, headlights, air-conditioner, defroster, and the like, and sensed data obtained from on-board sensors such as a raindrop sensor, an air temperature sensor, and the like. The data on the operating conditions of the on-board equipment and the sensed data can be utilized to estimate the weather at each moment in the traveling pattern predicting section 11.

[0052] Travel data storage section 15 stores the travel data acquired by the travel data acquiring section 13 and the travel environment data acquired by the travel environment data acquiring section 14. In this case, the travel data and travel environment data during one travel cycle of the vehicle are stored as mutually associated data. A candidate traveling speed pattern storing section 16 stores traveling speed patterns generated from the data gathered in previous travel as described later.

[0053] In the drive control system 10 of the present embodiment, when the traveling pattern predicting section 11 executes the traveling speed pattern estimation routine and estimates a traveling speed pattern, the main control unit 26 sets a schedule relating to the usage ratio between the engine 21 and the motor 24 on the basis of the estimated traveling speed pattern, and controls the operational states of the engine 21 and the motor 24 and the SOC of the battery 23 in accordance with the thus set schedule.

[0054] The drive control system 10, in consideration of its function as a vehicle

traveling speed estimation device, has traveling information storing means, candidate traveling speed pattern generating means, and estimated traveling speed pattern outputting means. The traveling information storing means, which stores travel data and travel environment data as mutually associated data, is related to the travel data storage section 15. The candidate traveling speed pattern generating means, which generates candidate traveling speed patterns on the basis of travel data, is related to the traveling pattern predicting section 11. Furthermore, the estimated traveling speed pattern outputting means, which extracts candidate traveling speed patterns matching current travel environment data and outputs an estimated traveling speed pattern for a route to be followed from the current position, is related to the traveling pattern predicting section 11. Moreover, the drive control system 10 for the hybrid vehicle may have frequently traveled route specifying means for specifying a frequently used route on the basis of the travel data and sectional dividing means for dividing the frequently used route into short sections. In this case, the frequently used route specifying means and the sectional dividing means are related to the traveling pattern predicting section 11.

[0055] Next, the operation of the drive control system 10 mentioned above will be described. First of all, the basic concept of estimating a traveling speed pattern will be described.

[0056] As a rule, in a hybrid vehicle, travel control of the vehicle is performed to match a driver's real-time demand for operation and a demand made by the electric charge accumulation means. However, generally accepted travel control of a hybrid vehicle has the following problems (1) to (8).

[0057] (1) In a traveling speed pattern wherein the vehicle is stopped immediately after having accelerated or in a traveling speed pattern wherein the vehicle is frequently accelerated or decelerated, the engine is in operation only for a short period, so that a battery cannot be charged sufficiently in some cases.

[0058] (2) Even if the battery is charged with a large amount of electricity while the power required for driving the vehicle is low, the engine may be in operation.

[0059] (3) Even if the energy required for driving the vehicle between start and stop thereof is low, the engine may be in operation.

[0060] (4) Even if the power required for driving the vehicle is low, as in the

case of being trapped in traffic congestion or traveling at a low speed, a decrease in the amount of electricity accumulated in the battery may cause the engine to operate so as to generate electricity by means of a generator.

[0061] (5) Even if regenerative current is generated, as in the case of traveling downhill or decelerating, a certain management range of the SOC of the battery may not permit regeneration.

[0062] (6) If the engine is in operation in the case where the energy required for powering the vehicle is low, as in the case of traveling at a constant speed, the generator generates current. However, a certain management range for the SOC of the battery may not permit accumulation of electric charge.

[0063] (7) Even if the vehicle is decelerating or is about to be stopped, the engine may be in operation.

[0064] (8) In summer, even if the vehicle is stopped, the engine may be in operation to keep an air-conditioner in operation.

[0065] To solve the problems mentioned above, it is necessary to estimate a traveling speed pattern on a route estimated to be followed from the current position, to set an operational schedule for traveling along the route efficiently, and to control the operational states of the engine 21 and the motor 24 and the SOC of the battery 23 in accordance with the operational schedule. In the present embodiment, therefore, candidate traveling speed patterns are produced on the basis of the past data for travel along routes that are frequently followed for the purpose of going to work, going to school, going shopping, and the like. Then, the one pattern which best corresponds to current travel environment data is extracted from the candidate traveling speed patterns, and a traveling speed pattern for the route estimated to be followed from the current position is estimated.

[0066] In this case, the routes that are frequently traveled are certain routes followed almost every day, for example, a commute route. However, they need not be followed every day. That is, they may be followed every other day or more or less once a week. Also, these routes need not be followed periodically. That is, the frequency with which they are followed may be appropriately determined. Time zones in which the routes to be frequently used are traveled may be constant as in the case of going to work in the morning, or may vary daily as in the case of

going home after work. The distances of the routes frequently traveled may either be short such as 2 to 3 km or long such as 100 km. It should be noted that herein outbound and homeward routes are treated as different routes as to any one of the above-mentioned routes frequently traveled.

[0067] Next, the overall operation of estimating a traveling speed pattern will be described with reference to Fig. 3. First of all, as in the case where a conventional navigation system executes navigation processing, the traveling pattern predicting section 11 transmits travel data acquired by the travel data acquiring section 13 to the travel data storing section 15, which then stores and accumulates the data (step S1). Further, the traveling pattern predicting section 11 transmits travel environment data acquired by the travel environment data acquiring section 14 to the travel data storing section 15, which then stores the data. In this case, the travel data and travel environment data during one travel cycle of the vehicle are stored as mutually associated data. One travel cycle of the vehicle means a journey between start and stop of the vehicle, namely, a journey between start and stop of the drive unit 20.

[0068] Then, the traveling pattern predicting section 11 executes a routine for specifying a route as a frequently followed route, on the basis of the travel data stored and accumulated in the travel data storing section 15 (step S2). In this case, routes that have been followed by the vehicle at least a predetermined number of times are specified and registered as frequently traveled routes.

[0069] Then, the traveling pattern predicting section 11 executes a candidate traveling speed pattern generation routine for generating a candidate traveling speed pattern (step S3). In this case, the traveling pattern predicting section 11 divides each of the frequently used routes into a plurality of short sections, classifies the past travel data in each of the short sections, usually into a plurality of classes, generates a representative traveling speed pattern for each of the classes on the basis of the travel data thus classified, and sets the representative traveling speed pattern as a candidate traveling speed pattern. Hence, a plurality of candidate traveling speed patterns are usually generated for each of the short sections. There may also be a short section which corresponds to only one class and for which only a single candidate traveling speed pattern is generated.

[0070] Then, the traveling pattern predicting section 11 executes a traveling

speed pattern estimation routine for estimating a traveling speed pattern for a route estimated to be followed (step S4). In this case, the traveling pattern predicting section 11 extracts that data which corresponds to current travel environment data from the travel data accumulated in the travel data storing section 15, and selects, for each of the short sections, a candidate traveling speed pattern to which the greatest number of past travel items of data thus extracted belong, as an estimated traveling speed pattern. The traveling pattern predicting section 11 then connects estimated traveling speed patterns selected for the respective short sections, and outputs them as a traveling speed pattern for the route estimated to be followed from the current position.

[0071] Next, the frequently traveled ("used") route specification routine will be described in detail.

[0072] Fig. 4 is a flowchart showing the routine for specifying the frequently used routes. First of all, after having acquired travel data during one travel cycle of the vehicle, the traveling pattern predicting section 11 collates the current travel data thus acquired with the past travel data accumulated in the travel data storing section 15, and confirms how many times the currently followed route has been followed in the past (step S2-1). In this case, it is more efficient to specify the currently followed route by collating the current travel data with the data stored in the navigation data base 12 by means of a map matching function utilized in the navigation processing and to confirm the number of times the route has been followed in the past, than to directly compare the current travel data with the past travel data.

[0073] Then, the traveling pattern predicting section 11 determines whether or not the same route as currently followed has been followed at least a predetermined number of times (e.g., ten times) or more (step S2-2). If it is determined that the route has been followed the predetermined number of times or more, the traveling pattern predicting section 11 specifies and registers the route currently followed as a frequently used (or "traveled") route, and terminates execution of the routine (step S2-3). If it is determined that the route has not been followed at least the predetermined number of times, the traveling pattern predicting section 11 terminates execution of the routine without specifying or registering the route currently followed as a frequently used route.

[0074] Next, the candidate traveling speed pattern generation will be described with reference to Figs. 5-14. Firstly, the traveling pattern predicting section 11 acquires accumulated travel data for a registered frequently used route from the travel data storing section 15 (step S3-1). The traveling pattern predicting section 11 acquires the road data stored in the navigation data base 12, and divides the frequently used route into a plurality of short sections on the basis of the road data (step S3-2).

[0075] In the present embodiment, the traveling pattern predicting section 11 divides the frequently used route according to intersections. In general travel, the vehicle tends to travel without stopping between intersections, and it is considered that the traveling speed pattern between the intersections is likely to be substantially constant because of the road width or the usual degree of congestion. Further, it is considered that traveling speed patterns before and after passing an intersection tend to be greatly different from each other, depending on whether or not the vehicle stops at the intersection. Hence, in order to generate candidate traveling speed patterns for a short section, it is desirable to divide a frequently used route according to intersections. Items of information on position, etc., of the intersections are included in the intersection data. It is possible to determine, on the basis of the intersection data, how the accumulated travel data for the frequently used route is to be divided. Thus, for each of the intersections, the frequently used route is divided into a plurality of short sections, for example, four short sections A to D as shown in Fig. 5. It is to be noted herein that S denotes the start location of the frequently used route and that G denotes the end location of the frequently used route. The divided travel data corresponding to the short section B is shown, by way of example, in Fig. 6. Referring to Fig. 6, the abscissa represents the distance from the start of the short section B, the ordinate represents a speed for each distance, and curves represent traveling speed patterns corresponding to the travel data, respectively.

[0076] Then, the traveling pattern predicting section 11 calculates an entire-section average travel speed for each of the short sections of the frequently used route, on the basis of the accumulated travel data for the frequently used route (step S3-3). In this case, the entire-section average travel speed is an average travel speed for each of the short sections as a whole, and is calculated

for each item of the travel data. The travel data is acquired and accumulated every time the frequently used route is driven. Therefore, an entire-section average travel speed for each of the short sections is calculated for each item of the travel data that is equal in number to the number of times of travel along the frequently used route.

[0077] The traveling pattern predicting section 11 extracts, from the travel data, that data which has mutually close entire-section average travel speeds, defines the extracted data as one set, and thereby classifies the travel data into sets based on entire-section average travel speed (step S3-4). The travel data is classified as to each of the short sections of the frequently used route. In this case, the travel data is classified, for example, using a clustering method called a "k"-average method.

[0078] For instance, the travel data corresponding to the short section B as shown in Fig. 6 is classified into three sets as is apparent from Figs. 7, 8, and 9. Referring to Figs. 7, 8, and 9, the abscissa represents the distance from the start of the short section B, the ordinate represents a speed for each distance, and curves represent traveling speed patterns corresponding to the travel data, respectively. In this case, if the classification uses the clustering method, called the "k"-average method, on the basis of an entire-section average travel speed that has been calculated as an average travel speed for the entire short section B, as to each of the curves shown in Fig. 6, classes B-1, B-2, and B-3 as shown in Figs. 7, 8, and 9 are obtained. It is apparent from Figs. 7, 8, and 9 that the travel data in each of the sets classified on the basis of the entire-section average travel speed have more or less similar traveling speed patterns.

[0079] Then, for each of the classified sets, the traveling pattern predicting section 11 calculates a position average travel speed at each position between the start and end of each of the short sections, using the travel data belonging to the set. This position average travel speed is an average travel speed corresponding to each item of the travel data, for example, as determined at each of plural predetermined distances from the start position. Then, the traveling pattern predicting portion 11 generates a continuous set of position average travel speeds for respective positions from the start to the end, namely, a transition in the position average travel speed, and defines the transition in the position average

traveling speed as a representative travel speed pattern of the set (step S3-5).

[0080] For example, representative traveling speed patterns as shown in Figs. 10, 11, and 12 are generated on the basis of the travel data belonging to the sets of the classes B-1, B-2, and B-3 as shown in Figs. 7, 8, and 9, respectively. Referring to Figs. 10, 11, and 12, the abscissa represents the distance from the start of the short section B, the ordinate represents a speed for each distance, and the lines represent representative traveling speed patterns, respectively. Each of the representative traveling speed patterns is obtained by calculating position average travel speeds by simply averaging travel speeds corresponding to the travel data at the respective positions, and by continuously connecting the position average travel speeds from the start to the end of the short section B.

[0081] In calculating a position average travel speed for each position, it may be calculated by simply averaging travel speeds corresponding to the respective travel data at each position. Alternatively, it is also possible to use weighting by adding a weighting factor that becomes more influential as travel data becomes more recent. In estimating a traveling speed pattern for each of the short sections in the traveling speed pattern estimation processing, the representative traveling speed pattern is treated as a candidate. In the present embodiment, therefore, the representative traveling speed pattern will hereinafter be referred to as a candidate traveling speed pattern. A candidate traveling speed pattern thus generated is transmitted to and stored in the candidate traveling speed pattern storing section 16.

[0082] In classifying travel data into sets, it is possible to utilize a method based on the degree of similarity among traveling speed patterns as well as a method based on the entire-section average travel speed, as mentioned above. When travel data for each of the short sections is drawn as curves indicating traveling speed patterns in two dimensions, wherein the abscissa represents the distance from the start of the short section and wherein the ordinate represents the speed for each distance as shown in Fig. 6, "the degree of similarity among traveling speed patterns" means the degree of similarity among shapes of the curves. Travel data whose curves indicating traveling speed patterns which are similar to one another are extracted and classified into one set. In this case, the traveling pattern predicting section 11 performs the following operations (1) and

(2).

[0083] (1) First of all, some travel data is arbitrarily selected.

[0084] (2) Then, as to each item of the selected travel data:

[0085] (2-1) a square of a difference in speed between the selected travel data and other travel data (i.e., a square error) at each position between the start and end of the short section is calculated; and

[0086] (2-2) if the square error at each of the positions is within a predetermined range, the above-mentioned other travel data is regarded as belonging to the same set as the selected travel data.

[0087] The above-mentioned operations (1) and (2) are thereafter repeated for each of the short sections.

[0088] In the method based on entire-section average travel speed as mentioned above, travel data is classified by having each item of the travel data represented by a scalar called entire-section average travel speed, and by applying the "k"-average method to the scalar. On the other hand, in the method based on the degree of similarity among traveling speed patterns, travel data is classified by expressing the travel data as vectors called speed sequences, and by applying the "k"-average method to the vectors. Therefore, according to the aforementioned method based on the degree of similarity among traveling speed patterns, despite an increase in the amount of calculation, travel data having similar traveling speed patterns can be more appropriately classified.

[0089] An example of the result of a classification carried out as to all the short sections of a frequently used route is illustrated in Fig. 13. In this case, travel data is classified into one set (A-1) for the short section A, three sets (B-1, B-2, and B-3) for the short section B, two sets (C-1 and C-2) for the short section C, and two sets (D-1 and D-2) for the short section D. In Fig. 13, the sets for the respective short sections are indicated by respective ellipses. Although not shown, candidate traveling speed patterns corresponding to the respective sets are generated.

[0090] Relationships between the sets in the short sections adjacent to each other, namely, between the upstream-side short section (on the left side in the drawing) and the downstream-side short section (on the right side in the drawing) are expressed by segments connecting the sets to one another. Each of

numerals surrounded by circles on the segments represents the number of items of travel data which belong to the set(s) in the upstream-side short section and which belong to the sets in the downstream-side short section.

[0091] In the example shown in Fig. 13, it is apparent that the total number of items of travel data is 50 and that all the travel data belongs to the single set A-1 in the short section A. In the short section B, it is apparent from the segments connecting the sets to one another and the numerals surrounded by the circles on the segments that 10, 15, and 25 out of the 50 items of travel data belonging to set A-1 belong to the sets B-1, B-2, and B-3 respectively. By the same token, in the short section C, eight and two out of the 10 items of travel data belonging to the set B-1 belong to the sets C-1 and C-2 respectively. Also, eight and seven out of the 15 items of travel data belonging to the set B-2 belong to the sets C-1 and C-2 respectively. It is to be noted herein that all 25 items of travel data belonging to the set B-3 belong to the set C-2. Furthermore, in the short section D, three and 13 out of the 16 items of travel data belonging to the set C-1 belong to the sets D-1 and D-2 respectively. Further, 24 and 10 out of the 34 items of travel data belonging to the set C-2 belong to the sets D-1 and D-2 respectively.

[0092] In the candidate traveling speed pattern generation in the present embodiment, no travel environment data is used. That is, the traveling pattern predicting section 11 acquires travel data from the travel data storing section 15 without acquiring travel environment data therefrom, and generates candidate traveling speed patterns on the basis of the travel data. Hence, travel data belonging to one set may include, for example, travel data for rainy days and travel data for sunny days.

[0093] Thus, the candidate traveling speed patterns are not generated on the basis of the travel environment data, but only on the basis of the travel data, because even if travel environments such as days of the week or weather are different, similar traveling speed patterns are obtained irrespective of the travel environments under certain road conditions. Under such circumstances, by generating candidate traveling speed patterns only on the basis of travel data, without taking travel environments into account, it becomes possible to generate candidate traveling speed patterns on the basis of a great number of items of travel data, and to enhance the reliability of the candidate traveling speed patterns

thus generated. For instance, in the case where there is only one travel datum for travel in a rainy environment, namely, in the case where there is only one travel datum for rainy days, even if a traveling speed pattern for an upcoming rainy day is estimated on the basis of the single traveling datum, the reliability of the estimated traveling speed pattern is low. On the other hand, in the case where there are nine items of travel data which do not concern rainy days but have similar traveling speed patterns as well as the travel datum for rainy days, if a traveling speed pattern for an upcoming rainy day is estimated on the basis of those 10 items of travel data, the reliability of the estimated traveling speed pattern is enhanced.

[0094] Next, the traveling speed pattern estimation will be described with reference to Figs. 15 and 16. First of all, the traveling pattern predicting section 11 determines whether or not the drive unit 20 has been started (step S4-1). If the drive unit 20 has been started, the traveling pattern predicting section 11 acquires the current position of the vehicle and the current time. If the drive unit 20 has not been started, the traveling pattern predicting section 11 terminates execution of the routine. Referring to the travel data accumulated in the travel data storing portion 15, the traveling pattern predicting section 11 determines whether or not the frequently used route is to be followed from the current position, on the basis of the acquired current position of the vehicle and the acquired current time (step S4-2). For example, in the case of a commute, if the current position is the driver's home and the current time is in a morning commute time zone, it can be determined, referring to the accumulated travel data, that a commute route registered as a frequently used route is to be followed.

[0095] If it is determined that the route is to be followed is not registered as a frequently used route, the traveling pattern predicting portion 11 terminates execution of the routine. However, if it is determined that the frequently used route is to be followed from the current position, the traveling pattern predicting section 11 acquires current travel environment data such as a day of the week, operating condition of a wiper, and the like, from the travel environment data acquiring portion 14 (step S4-3). Then, the traveling pattern predicting section 11 extracts, from the travel data storing section 15, the past travel data matching the current travel environment data acquired from the travel environment data

acquiring section 14 (step S4-4). In this case, the travel data and travel environment data acquired during one travel cycle of the vehicle are stored as mutually associated data. Therefore, by retrieval utilizing travel environment data, the travel data associated with the travel environment data matching the current travel environment data can be extracted as travel data matching the current travel environment data.

[0096] Then, as in the example shown in Fig. 13, the traveling pattern predicting section 11 specifies, among the sets of the travel data classified as to all the short sections of the frequently used route, that one set which has the greatest number of items of travel data matching the current travel environment data (step S4-5).

[0097] Referring now to the example shown in Fig. 13, it is assumed that a datum indicating an operating state of the wiper has been acquired as a current travel environment datum, and that three out of a total of 50 items of travel data are associated with the travel environment datum indicating the operating state of the wiper. In addition, it is assumed that all of the three items of travel data belong to the set A-1 for the short section A, that two of them and the other one belong to the set B-1 and the set B-2, respectively, for the short section B, that one of them and the other two belong to the set C-1 and the set C-2, respectively, for the short section C, and that two of them and the other one belong to the set D-1 and the set D-2, respectively, for the short section D. In this case, those sets to which have the greatest number of items of travel data matching the current travel environment data are the sets A-1, B-1, C-2, and D-1. Hence, the traveling speed pattern for the frequently used route to be followed can be estimated to most likely belong to the sets connected by segments indicated by heavy-line segments in Fig. 15.

[0098] Then, the traveling pattern predicting section 11 extracts a candidate traveling speed pattern for the set specified in each of the short sections from the candidate traveling speed pattern storing section 16 (step S4-6). The traveling pattern predicting section 11 outputs the extracted candidate traveling speed pattern as an estimated traveling speed pattern (step S4-7), and terminates the routine.

[0099] Thus, in the traveling speed pattern estimation, travel data matching

current travel environment data is extracted, and a candidate traveling speed pattern of that set having the greatest number of items of travel data is extracted as an estimated traveling speed pattern. Hence, a suitable estimated traveling speed pattern matching the current travel environment data is output. The estimated traveling speed pattern matching the current travel environment data is a candidate traveling speed pattern of a set having the greatest number of items of travel data matching the current travel environment data.

[00100] As described above, the candidate traveling speed pattern is generated, not on the basis of the travel environment data, but only on the basis of the travel data. That is, the candidate traveling speed pattern is generated on the basis of a great quantity of travel data. Hence, even if there is a small number of items of travel data matching certain travel environment data such as those for rainy days, an estimated traveling speed pattern can be output with high precision.

[00101] In general, weather, time zone, day of the week, settlement date, end of term, and the like are considered as travel environments affecting traveling speed patterns. The influence exerted by weather causes the traffic to flow slowly as a rule and even the same route is followed at a lower speed if it rains. The influence exerted in the case of time zone is that vehicles travel at lower speeds in the morning and evening commute time zones because of traffic congestion, and at high speeds after midnight, etc., because of low traffic density. The influence exerted by the day of the week is that vehicles travel at high speeds on Sundays because of low traffic density. The settlement date is a day ending with 5 or 0, the last day of the month or the like, which is generally set as a closing date for transaction or accounting. Because the traffic increases in volume on such a settlement date, vehicles travel at lower speeds. The end of term is the end of March, the end of the year or the like, which is generally set as a settlement period. Because the traffic also increases in volume during the end of such a term, vehicles travel at lower speeds. Moreover, a temporary closure of the traffic that results from an unforeseen traffic accident, traffic congestion of unknown origin, a festival, an event such as a demonstration or the like, fire fighting, or the like, a closure of the traffic or traffic regulation that is caused by road construction or the like for a predetermined period, and the like can also be considered travel environments affecting traveling speed patterns.

[00102] Next, the operation of the drive unit 20 based on the estimated traveling speed pattern will be described with reference to Figs. 17-19. The main control unit 26 acquires an estimated traveling speed pattern from the traveling pattern predicting section 11 (step S11), and executes the scheduling routine for setting an operational schedule for controlling the operational states of the engine 21 and the motor 24 and the SOC of the battery 23, on the basis of the estimated traveling speed pattern. After having set the operational schedule, the main control unit 26 controls the operations of the engine 21, the engine control unit, the motor 24, the generator 22, and the inverter according to the operational schedule, and executes a travel routine for travel of the vehicle.

[00103] After having acquired the estimated traveling speed pattern, the main control unit 26 acquires a current SOC detected by the capacity detecting sensor of the battery 23 (step S12). In this case, since the scheduling routine is executed immediately before starting travel on a frequently used route, the current SOC is an SOC at the start location on the frequently used route, namely, an SOC at the departure location.

[00104] Then, the main control unit 26 sets an SOC for the end of the frequently used route, namely, an SOC at the destination (step S13). In this case, the SOC at the destination is equal, for example, to the SOC at the departure location of the frequently used route. However, the SOC at the destination can be set arbitrarily within a range of management of SOC.

[00105] In the drive control system 10 for the hybrid vehicle of the present embodiment as well, as in the case of a conventional hybrid vehicle, a range of management of SOC as an amount of electric charge accumulation in the battery 23 is set in advance, and an operational schedule is set such that the SOC is confined within the management range. As in the case of a conventional battery, the voltage-current characteristic of the battery 23 fluctuates depending on SOC, and the life span of the battery 23 is shortened by too large a SOC or too small a SOC. For instance, the battery 23 may be destroyed if charged excessively. Thus, the management range set in advance is set, for example, such that maximum and minimum values of SOC become approximately 60 % and 40 % respectively, and the SOC of the battery 23 is so controlled as to be confined within the management range.

[00106] However, in the case where the generator 22 quite often generates regenerative current, as in the case of a long downhill run, , if the management range is fixed, the regenerative current is wasted without being allowed to be sufficiently recovered by the battery 23. Hence, the amount of fuel consumption cannot be reduced sufficiently although the generator 22 quite often generates regenerative current.

[00107] Thus, the main control unit 26 sets an efficient operational schedule such that the amount of fuel consumption can be sufficiently reduced by allowing sufficient regenerative current to be recovered by the battery 23 while the SOC is prevented from exceeding the management range by adjusting upper-limit and lower-limit values of the management range and by widening the management range as necessary (step S14). That is, the main control unit 26 sets an operational schedule corresponding to a minimum amount of fuel consumption by the engine 21 on the basis of an estimated traveling speed pattern.

[00108] Then, the main control unit 26 sets an operational schedule for controlling the operational states of the engine 21 and the motor 24 and the SOC of the battery 23 according to the estimated traveling speed pattern that has been acquired, and determines whether or not there is an abnormality in the set operational schedule (step S15). The abnormality means that the SOC at the destination included in the set operational schedule is different from an originally set value, or that the SOC included in the set operational schedule exceeds the management range. If there is an abnormality, the main control unit 26 again sets an operational schedule. It is also appropriate that items of information on fuel consumption amount and a vehicular system be included in the operational schedule, and that a determination of the presence of an abnormality in the operational schedule be made on the basis of the items of information on amount of fuel consumption and the vehicular system.

[00109] For example, since the efficiency when powered by the engine 21 is low in a congested section, it is desirable to travel by the motor 24. Thus, as shown in Fig. 17(a), in the case where a congested section is included in an estimated traveling speed pattern output by the traveling pattern predicting portion 11, namely, in the case where the occurrence of traffic congestion is predicted beforehand, the main control unit 26 sets a driving method such that the battery 23

is sufficiently charged before reaching the congested section.

[00110] In the case where the upper-limit or lower-limit value of the management range of the SOC is not adjusted, the SOC changes as shown in Fig. 17(b). That is, since the vehicle travels by the motor 24 over a long distance in the congested section and consumes a large amount of current, it is necessary for the vehicle to travel in a generating mode wherein the engine 21 is in operation while the generator 22 generates electricity as indicated by "A", so as to prevent the SOC from dropping below the lower-limit value. Hence, the amount of fuel consumption cannot be reduced sufficiently. Further, since the vehicle reaches the destination soon after passing the congested section, a sufficient amount of electricity cannot be generated, and the SOC at the destination cannot be equalized with the SOC at the position of departure.

[00111] On the other hand, if the upper-limit value of the management range of the SOC is adjusted by being raised to a suitable value, the SOC changes as shown in Fig. 17(c). In this case, it can be detected that a regenerative section where regenerative current is generated exists in a section before the congestion section. Since the battery 23 can be sufficiently charged in the regenerative section, even if the vehicle travels by the motor 24 over a long distance in the congested section and consumes a large amount of current, the SOC can be held at a suitable value without operating the engine 21 as indicated by "B". Hence, the amount of fuel consumption can be sufficiently reduced. Further, the SOC at the destination can also be equalized with the SOC at the point of departure.

[00112] For example, also in a section where the vehicle often accelerates/decelerates or starts/stops, since the efficiency in traveling by the engine 21 is low, it is desirable that the vehicle travel by the motor 24. Thus, as shown in Fig. 18(a), if a section where the vehicle often accelerates/decelerates or starts/stops is included in an estimated traveling speed pattern output by the traveling pattern predicting portion 11 and if a section where the vehicle can stably travel is included immediately following that section, the main control unit 26 sets a driving method such that the battery 23 is charged after the section where the vehicle often accelerates/decelerates or starts/stops has been passed.

[00113] In the case where the upper-limit or lower-limit value of the management range of the SOC is not adjusted, the SOC changes as shown in Fig.

18(b). That is, since the vehicle travels by the motor 24 over a long distance and consumes a large amount of current in the section where the vehicle often accelerates/decelerates or starts/stops, it is necessary for the vehicle to travel in a generating mode wherein the engine 21 is in operation and wherein the generator 22 generates electricity as indicated by "C", so as to prevent the SOC from dropping below the lower-limit value. Therefore, the amount of fuel consumption cannot be sufficiently reduced.

[00114] On the other hand, if the lower-limit value of the management range of the SOC is adjusted by reduction to a suitable value, the SOC changes as shown in Fig. 18(c). In this case, regenerative current can be recovered by the battery 23 before the starting location position of a regenerative section immediately following the section where the vehicle often accelerates/decelerates or starts/stops. Hence, the battery 23 can be sufficiently charged in the regenerative section. Therefore, even if the vehicle travels by the motor 24 over a long distance and consumes a large amount of current in the section where the vehicle often accelerates/decelerates or starts/stops, the SOC can be held within the management range without operating the engine 21 as indicated by "D". Therefore, the amount of fuel consumption can be sufficiently reduced. In the section immediately following the section where the vehicle often accelerates/decelerates or starts/stops, the SOC can be recovered by sufficiently charging the battery 23. In the example shown in Fig. 18(c), the upper-limit value of the management range of the SOC is raised as well. This is because a congested section is included in the frequently used route, as in the example shown in Fig. 17(c). In the case where no congested section is included in the frequently used route, it is appropriate to adjust only the lower-limit value of the management range of the SOC.

[00115] As described above, the main control unit 26 detects a regenerative section on the basis of an estimated traveling speed pattern, and sets an operational schedule such that regenerative current can be recovered by the battery 23 before the starting location of the regenerative section. Therefore, no regenerative current is wasted. Further, since the operational schedule is set such that all the regenerative current generated in the regenerative section can be recovered by the battery 23, the amount of fuel consumption can be sufficiently

reduced.

[00116] Next, the operation of the traveling processing will be described with reference to Fig. 20. If the vehicle starts traveling along the frequently used route, the main control unit 26 controls the operations of the engine 21, the engine control unit, the motor 24, the generator 22, and the inverter according to the set operational schedule. In this case, the main control unit 26 acquires an SOC detected by the capacity detecting sensor of the battery 23, namely, an actual SOC on a real-time basis, compares the acquired SOC with an SOC included in the operational schedule (step S21), and determines whether or not there is an abnormality in the acquired SOC (step S22).

[00117] The actual traveling speed pattern of the vehicle along the route will not completely coincide with the estimated traveling speed pattern. Therefore, changes in actual SOC are considered to be different from changes in the SOC included in the aforementioned operational schedule. Hence, if the difference between an actual SOC and the SOC included in the operational schedule remains above a preset threshold for a while, the main control unit 26 determines that there is an abnormality, and resets an operational schedule from the current position of the vehicle at that moment to the destination (step S25). If there is no abnormality, the main control unit 26 continues to perform the control according to the operational schedule (step S23). Also in the case where the actual SOC has risen above or dropped below the upper-limit or lower-limit value of the management range, the main control unit 26 may determine that there is an abnormality, and may reset the operational schedule in use from the current position of the vehicle to the destination. In addition, if the actual SOC has risen above or dropped below the upper-limit or lower-limit value of the management range, the main control unit 26 may control the operations of the engine 21, the engine control unit, the motor 24, the generator 22, and the inverter so that the SOC is again confined within the management range, and may cause charge or discharge of the battery 23.

[00118] If the current position of the vehicle remains off the frequently used route for a while, the main control unit 26 determines that the vehicle is not traveling along the frequently used route, acquires navigation information and the like from the navigation data base 12, and resets the operational schedule from

the current position of the vehicle to the destination. In addition, also in the case where the current position of the vehicle has deviated from the frequently used route because of a temporary detour or the like, the main control unit 26 resets the operational schedule from the current position of the vehicle to the destination. If the current position of the vehicle has not greatly deviated from the frequently used route, the main control unit 26 continues to perform control according to the set operational schedule, as in the case where the difference between the actual SOC and the SOC included in the operational schedule is equal to or smaller than the preset threshold.

[00119] Then, the main control unit 26 determines whether or not the vehicle has reached the destination (step S24). If the vehicle has not reached the destination, the main control unit 26 repeats the aforementioned operation.

[00120] As previously described, in the present embodiment, the traveling pattern predicting section 11 of the drive control system 10 of the hybrid vehicle generates candidate traveling speed patterns by analyzing travel data in the case of travel along a route frequently followed for the purpose of going to work, going to school, going shopping, or the like, and outputs a suitable estimated traveling speed pattern corresponding to current travel environment data. Then, the main control unit 26 sets an operational schedule on the basis of the estimated traveling speed pattern, and controls the operations of the engine 21, the engine control unit, the motor 24, the generator 22, and the inverter according to the operational schedule. Thus, the SOC can be held at a suitable value, and the amount of fuel consumption of the engine 21 can be sufficiently reduced.

[00121] In this case, the traveling pattern predicting section 11 divides the frequently used route into short sections, and generates candidate traveling speed patterns for each of the short sections, not on the basis of travel environment data such as date, hour, day of the week, weather and the like, but only on the basis of travel data. Thus, the candidate traveling speed patterns can be generated on the basis of a great quantity of travel data and the precision of the candidate traveling speed patterns is enhanced.

[00122] Further, the traveling pattern predicting section 11 extracts travel data matching current travel environment data, extracts a candidate traveling speed pattern of a set in which the greatest number of items of travel data match the

current travel environment data, and sets the extracted candidate traveling speed pattern as the estimated traveling speed pattern to be used in current travel. Thus, it is possible to output a suitable estimated traveling speed pattern corresponding to the current travel environment data.

[00123] Thus, the candidate traveling speed patterns are generated, not on the basis of travel environment data, but only on the basis of travel data obtained in following the same frequently used route. In the case where an estimated traveling speed pattern for a frequently used route to be followed from now on is output, a candidate traveling speed pattern having the set of data items including in that set the greatest number of the items of travel data matching the current travel environment data is selected. Thus, a greater number of items of travel data can be used in generating candidate traveling speed patterns, and the selection of travel data can be suitably carried out on the basis of travel environment data in outputting an estimated traveling speed pattern to be used for current travel.

[00124] In addition, the traveling pattern predicting section 11 stores the past travel data for each of the short sections in the candidate traveling speed pattern storing section 16 as a plurality of candidate traveling speed patterns. Therefore, aggregation of data and reduction of storage capacity can be realized.

[00125] Furthermore, the traveling pattern predicting section 11 outputs an estimated traveling speed pattern by extracting candidate traveling speed patterns matching travel environment data in future travel. Thus, the burden of calculation processing is reduced in comparison with a case where an estimated traveling speed pattern is output on the basis of an enormous volume of the past travel data, and the estimated traveling speed pattern can be output more quickly.

[00126] Furthermore, in setting a schedule for efficient travel along the route, the main control unit 26 adjusts an upper-limit or lower-limit value of a management range of SOC, widens the management range as necessary, and sets a driving method. Thus, it is possible to provide efficient driving such that the amount of fuel consumption can be minimized by allowing the battery 23 to sufficiently recover regenerative current while preventing the SOC from exceeding the management range.

[00127] It should be noted that the present invention is not limited to the

above-mentioned embodiment but can be modified in various manners consistent with the basic concept, and that modifications of the present invention should not be excluded from the scope thereof.

[00128] As previously described in detail, according to the present invention, a vehicle traveling speed pattern estimation device comprises traveling information storing means for storing travel data and travel environment data as mutually associated data, candidate traveling speed pattern generating means for generating a candidate traveling speed pattern on the basis of the travel data alone, and estimated traveling speed pattern outputting means for extracting a candidate traveling speed pattern matching current travel environment data and outputting an estimated traveling speed pattern for the route to be followed.

[00129] Again, when a candidate traveling speed pattern is generated, it is generated, not on the basis of travel environment data, but only on the basis of travel data. In outputting an estimated traveling speed pattern for a route to be followed, the candidate traveling speed pattern best matching current travel environment data is selected. Therefore, an estimated traveling speed pattern can be output with high precision while minimizing the burden of calculation.

[00130] Optionally, the vehicle traveling speed pattern estimation device further comprises frequently used route specifying means for specifying a frequently used route on the basis of the travel data, and sectional dividing means for dividing the frequently used route into short sections. The candidate traveling speed pattern generating means generates candidate traveling speed patterns for each of the short sections. The estimated traveling speed pattern outputting means extracts a candidate traveling speed pattern for each of the short sections, and outputs an estimated traveling speed pattern for a frequently used route to be followed.

[00131] Since an estimated traveling speed pattern for a route that is frequently followed is output, the estimated traveling speed pattern can be output quickly with high precision. Because the frequently used route is divided into the short sections, and the candidate traveling speed pattern is extracted for each of the short sections, the estimated traveling speed pattern can be output quickly with higher precision.

[00132] Optionally, the candidate traveling speed pattern generating means classifies travel data for each of the short sections on the basis of an average

travel speed for each of the short sections or a degree of similarity among traveling speed patterns for each of the short sections, and generates, as the candidate traveling speed pattern, a traveling speed pattern representing a set of the classified travel data for each of the short sections.

[00133] This classification is made on the basis of an average travel speed for each of the short sections or a degree of similarity among traveling speed patterns for each of the short sections, and a traveling speed pattern representing a set of classified travel data for each of the sections is defined as a candidate traveling speed pattern. Therefore, a suitable candidate traveling speed pattern can be generated.